M.Sc. in Oceanography
2016/2017

1. INTRODUCTION

The M.Sc. Programme in Oceanography seeks to provide a sound theoretical and practical knowledge and comprehensive training in the application of scientific knowledge to understand the phenomena of the oceanic and coastal environments.

Sri Lanka is an island surrounded by sea with a 200 nautical mile Exclusive Economic Zone (EEZ) and legal continental margin extending to several hundreds of miles beyond the limits of this zone. Sri Lankan coastline is characterized by sandy beaches, extensive lagoons, estuaries, mangroves, coastal marshes and dunes. Seaward of the coastline, reefs of coral or sandstone and shallow beds of coastal and estuarine seagrass are found on the continental shelf. As far as the minerals are concerned, the depletion of recoverable land resources has made mankind turn to oceans, estuaries, lagoons to satisfy the needs of the expanding world. For example, in the ocean lie large deposits of petroleum and other minerals adequate to cater to the needs of mankind for years to come. Also an understanding of sea water currents, tides, waves, salinity, temperature, dissolved gases as well as mathematical modeling of the sea and adjacent water bodies will be helpful to (a) locate suitable fishing grounds (b) predict the climate and take decisions on protecting the coastline of the country. However, the lack of expertise of the subject in the country is a great barrier to overcome in finding solutions to the above problems. In this programme, it is intended to give an opportunity for the students to get a better insight into the marine environment and eventually with perhaps further training to provide the required expertise to the country.

2. AIMS AND OBJECTIVES

The programme is designed with a view to:

1. Promoting and conducting research activities directed towards the identification, assessment, management and development of aquatic resources, particularly, the fields of marine and adjacent water bodies

2. Providing advisory and consultancy services on scientific, technological and legal matters relating to exploitation, research development, control and management of living and non-living aquatic resources.

3. Ensuring the application and utilization of scientific and technological expertise for the implementation of the national development programmes on the subject of marine resources.
3. PROGRAMME ELIGIBILITY

Graduates in any scientific discipline are eligible for admission though it is desirable that candidates should have a strong background in at least one of the following subjects: geology, physics, chemistry, mathematics, engineering or biology.

Employed candidates who are eligible for admission should produce evidence of leave granted to follow the programme and a letter of release from the relevant Head of the Department/Institution.

4. PROGRAMME FEE

<table>
<thead>
<tr>
<th></th>
<th>M.Sc. programme fee</th>
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<tbody>
<tr>
<td>local candidates</td>
<td>Rs. 150000/-</td>
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<tr>
<td>SAARC countries</td>
<td>US $ 5000/-</td>
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<tr>
<td>other countries</td>
<td>US $ 10000/-</td>
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</tbody>
</table>

Programme fees shall be paid in two instalments (50% at registration and remaining 50% within six months from registration). Other payments including registration fee, medical fee, library subscription, examination fee and deposits (science and library) should be paid according to the procedure stipulated by the PGIS.

5. THE PROGRAMME STRUCTURE AND DURATION

This is a full-time programme consisting of course work and a research project. Coursework will be conducted over a period of two semesters of 15 weeks each, during Fridays (if necessary), Saturdays and Sundays. The entire programme duration will be about 15-18 months inclusive of 3-6 months for the research project. Satisfactory completion of a minimum of 24 credits of course work (with a GPA of not less than 3.00) is required for the programme in addition to the six credits allocated for the full-time research project (If the student obtains a GPA in the range 2.75 to 2.99, then he/she is eligible only for the award of the Diploma in Oceanography). Continuous attendance is compulsory during the period of research work. After successful completion of the research project, the student is eligible for the award of the M.Sc. Degree. Based on the performance by students in the taught courses, PGIS may upgrade the registration of such students to M.Phil. or Ph.D. programmes.

Each candidate will be assigned an academic advisor, whose advice should be sought when planning the M.Sc. programme. The approval of the programme coordinator is necessary prior to the commencement of the programme. English will be the medium of instruction.
## Programme Summary

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course</th>
<th>Lecture Hrs.</th>
<th>Practical Hrs.</th>
<th>No. of Credits</th>
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<tbody>
<tr>
<td>Semester 1</td>
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<tr>
<td>ES 561</td>
<td>Biological Oceanography</td>
<td>30</td>
<td>-</td>
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<tr>
<td>ES 562</td>
<td>Physical Oceanography</td>
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<td>ES 563</td>
<td>Chemical Oceanography</td>
<td>30</td>
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<tr>
<td>ES 564</td>
<td>Oceanography Practical I</td>
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<td>60</td>
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<tr>
<td>ES 565</td>
<td>Marine Geology and Geophysics</td>
<td>30</td>
<td>-</td>
<td>2</td>
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<tr>
<td>ES 566</td>
<td>Surveying, Sampling and Analytical Techniques with special reference to Coastal Areas</td>
<td>30</td>
<td>-</td>
<td>2</td>
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<td>ES 567</td>
<td>Data Analysis using Statistical Software</td>
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<td>-</td>
<td>2</td>
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<tr>
<td>Semester 2</td>
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<tr>
<td>ES 576</td>
<td>Oceanography Practical II</td>
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<td>60</td>
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<tr>
<td>ES 577</td>
<td>Computational Methods in Oceanography</td>
<td>30</td>
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<tr>
<td>ES 578</td>
<td>Estuarine and Coastal Oceanography</td>
<td>30</td>
<td>-</td>
<td>2</td>
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<tr>
<td>ES 579</td>
<td>Dynamic Oceanography *</td>
<td>30</td>
<td>-</td>
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<tr>
<td>ES 580</td>
<td>Physical and Inorganic Chemistry of Seawater *</td>
<td>30</td>
<td>-</td>
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<tr>
<td>ES 581</td>
<td>Marine Biodiversity and Conservation *</td>
<td>30</td>
<td>-</td>
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<tr>
<td>ES 582</td>
<td>Marine Geophysics *</td>
<td>30</td>
<td>-</td>
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<tr>
<td>ES 597</td>
<td>Seminar</td>
<td>-</td>
<td>15</td>
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<tr>
<td>ES 599</td>
<td>Research project (minimum of three months duration)</td>
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</tr>
</tbody>
</table>

* Optional Courses

## 6. PROGRAMME CONTENTS

### ES 561: BIOLOGICAL OCEANOGRAPHY


### Reference books

- Biological oceanography, 1999 - Lalli, C.M.
- Biological Oceanography (1997) The Open University/Butterworth Heinemann
ES 562 : PHYSICAL OCEANOGRAPHY

Reference books
Seawater, Its Composition, Properties and Behaviour, 1995–The Open University / Butterworth Heinemann

ES 563 : CHEMICAL OCEANOGRAPHY
Major and minor elements in seawater – Geochemical balance of the oceans, residence time, chemical speciation, constancy of relative ionic composition of seawater, conditions under which major elements may not be conservative, factors affecting the distribution of trace elements in the sea, interaction of trace elements with marine organisms, enrichment factor, conservative and non-conservative properties - Chlorinity and salinity: definition, significance and measurement, practical salinity scale – Radio activenuclides as tracers to study oceanic circulation pattern. Dissolved gases in seawater - Basic concepts: solubility of gases in seawater, air-sea gas exchange, processes affecting their distribution, dissolved oxygen in the ocean - Dissolved CO₂ in seawater - CO₂ equilibrium in seawater, pH, alkalinity and buffering capacity of oceans, components of CO₂ system in seawater - Percentage composition of inorganic carbon, calcium carbonate precipitation and dissolution phenomena - Lysocline and calcite compensation depth. Micronutrient elements (P, N and Si) in seawater - Forms in seawater, distribution and cycle, N:P ratios - Stoichiometry of the uptake and regeneration of the nutrient elements and of oxygen - Introduction to biogeochemical cycles and modeling - Chemistry of land-locked basins: hydrography, circulation, chemistry with examples (the Baltic and the Black Sea)- Reducing environments - Chemical oceanography of the seas around Sri Lanka.
Reference books
Ocean Chemistry and Deep Sea Sediments, 1989 - The Open Universit Butterworth Heinemann
Introduction to marine chemistry, 1981 - Riley, R.P. and Chester,
Chemical oceanography (Vol. 1, 2 and 3), 1975 - Riley, J.P. and Skirrow, G.
Marine chemistry, 1969 - Horne, R.A,
Seawater: Its composition, properties and behaviour, 1989 - The Open University
Marine chemistry (Vol. 2), 1970 - Margin, D.F.
Chemical oceanography, 1982 - Broecker and Peng.
Marine geochemistry, 1990 - Chester
Chemical oceanography, 1992 - Millero and Saha, M.L.
Dynamic processes in the chemistry of the upper ocean, 1986 - Burton et al, Plenum Press.
The chemistry of the atmosphere and oceans, 1978 - Holland, H.D.
An introduction to environmental chemistry, 1996 - Andrews et al, Blackwell Science
Environmental chemistry, 1994 - De A.K., Wiley-Eastern Ltd.

ES 564 : OCEANOGRAPHY PRACTICAL I
Practical relevant to ES 561, ES 562, ES 563 & ES 564

ES 565 : MARINE GEOLOGY & GEOPHYSICS

Reference books
Oceanography (5th Edn.), 1990 - Grant Gross, M., Prentice Hall
Coastal and estuarine sediment dynamics, 1986 - Dyer K.R., John Wiley & Sons
Beach processes and sedimentation, 1976 - Komar, P.D., Prentice Hall
Beaches and coasts (2nd Edn.), 1972 - King, C.A.M., Edward Arnold
Introduction to geophysical prospecting, 1976 - Dobrin, M.B., McGraw-Hill
Gravity and magnetics in oil prospecting, 1976 - Nettleton, L.L., McGraw-Hill
The mineral sources of the sea, 1965 - Mcro, J.L., Elsevier, Amsterdam
Earth resources, 1969 - Skinner, B.J., Prentice Hall
ES 566 : SURVEYING, SAMPLING AND ANALYTICAL TECHNIQUES WITH SPECIAL REFERENCE TO COASTAL AREAS
Instruments used for meteorological studies - Psychometer, anemometer, radio sonde, sun photometer samplers - Instruments used for physical oceanographic studies: mechanical bathythermograph, expendable bathythermograph, reversing thermometer, CTD probe, current meters samplers - Instruments used in chemical oceanography samplers - Instruments for sampling: grabs, corers, dredges, rock core drill, water samplers - Surveying, sampling and laboratory techniques for the study of marine sediments samplers

ES 567 : DATA ANALYSIS USING STATISTICAL SOFTWARE

ES 576 : OCEANOGRAPHY PRACTICAL II
Practical from OC21, OC22 and OC23

ES 577 : COMPUTATIONAL METHODS IN OCEANOGRAPHY
Descriptive Statistics – Sample, population – Measures of central tendency, dispersion: skewness, kurtosis – Correlation: simple correlation, Karl Pearson’s coefficient off correlation, concurrent deviation method, method of least squares (regression) – Regression equations – Binomial and normal distribution – Inferential statistics – Hypothesis testing, significance level – Student \( t \) test \( x^2 \) test, \( F \) test, standard error – Test of significance for attributes, large samples and small samples – Analysis of variance

Introduction to computers – FORTRAN programming: operators, relational operators, type declaration, READ, WRITE, FORMAT, DIMENSION, CONTINUE, GO TO STOP, END statements, intrinsic functions, arithmetic assign statement, DO loop, nested DO LOOP, arithmetic and logical IF statements, IF-ENDIF block statements, IF-ELSEIF-ENDIF block statements, computed GO TO statements – Introduction to C and VisualBasic

Reference books
A biologist’s basic mathematics, 1983 - Causton, D.R., Edward Arnold, London
Introduction to mathematics for life scientists, 1971-Batchelet, E
College algebra, 1966-Bardell, R.H. and Spitzbart, A, Addison-Wesley, Massachusetts, U.S.A.
ES 578 : ESTUARINE AND COASTAL OCEANOGRAPHY


Coastal ecosystems and their characteristic fauna and flora: sandy shores, rocky shores, estuaries, coral reefs – Adaptations of coastal and estuarine organisms – Effects of pollution on coastal fauna – Coastal living resources: algae, dominant crustaceans (major penaeid and non-penaeid prawns, crabs, horseshoe crabs, lobsters), dominant mollusces, holothurians and major teleost fishes.


Reference books

Estuarine chemistry, 1976 - Burton, J.D. and Liss, P.S.
Practical estuarine chemistry, 1985 - Head, P.C.
Chemistry and biogeochemistry of estuaries, 1980 - Olausson, E. and Cato, I.
Chemical oceanography (Vol. 7), 1978 - Riley, J.P. and Chester, R.
Waves, tides and shallow-water processes, 1991 - The Open University
Coastal and estuarine sediment dynamics, 1986 - Dyer, K.R., John Wiley & Sons
Estuarine hydrography and sedimentation, 1986 - Dyer, K.R. John Wiley & Sons
Beach processes and sedimentation, 1976 - Komar, P.D., Prentice Hall
Introduction to geochemistry, 1967 - Krauskopf, K.B., McGraw-Hill
Elements of ecology (3rd Ed.), 1982 - Tait, R.V.
Textbook of marine ecology, 1989 - Nair, N.B. and Thampy, D.M.

ES 579 : DYNAMIC OCEANOGRAPHY


Reference books

The dynamics of the upper ocean (2nd Edn.), 1977 - Phillips, O.M., Cambridge Univ. Press, U.K.
Modeling and prediction of the upper layers of the ocean, 1977 - Krous, E.B. (Ed.)

ES 580: PHYSICAL AND INORGANIC CHEMISTRY OF SEAWATER
The structure of liquid water - Theories of water structure, Colligative properties of seawater with the thermodynamic derivations of expressions for boiling point elevation and freezing point depression, electrostriction – The Thermodynamics of Seawater – Ideal and real solutions, equation of state for pure water and seawater, thermodynamics of PVT changes in seawater; activities, activity coefficients; Debye-Huckel limiting law; heat of solution, dilution and mixing – Transport processes in Solution – Dielectric relaxation, diffusion, viscosity and electrical conductivity.

Acids and bases – basic concepts, proton condition and the electroneutrality of solutions; pH as a master variable – log C – pH diagram for monoprotic and diprotic acid – base system; buffer pH, buffer intensity and acid – base neutralizing capacity – Oxidation and Reduction Reactions – Redox equilibria, electron activity and pE – Peters-Nernst equation; pE-pH diagram for the aqueous chlorine system, pE – pE diagram for Fe (II) Fe (III) system, Kinetics for redox processes (Oxidation of Fe (II) and Mn (II) only).

Metal Ions in Aqueous Solutions – hydrolysis of metal ions, the stability of hydrolysis species, complex formation and the solubility of solids: chelates – inorganic and organic complexes in natural waters – Precipitation and dissolution – Heterogeneous equilibria, solubility product and saturation; the solubility of oxides and hydroxides; carbonate system closed to atmosphere and in equilibrium with CO₂(g); the stability of hydroxides and carbonates; crystal formation – The initiation and production of the solid phase – Solubility equilibria for silicates, aluminosilicates and iron (oxy) hydroxides.

Reference books
Water chemistry, 1980 - Snocink, V.L and Jenkins, D., John Wiley & Sons, New York
Principles of aquatic chemistry, 1983 - Morel, E.M.M.
Chemical kinetics and process dynamics in aquatic systems, 1994 - Brezonik, P.L., Lewis Publ., London
Aquatic surface chemistry, 1987 - Stumm, W., Wiley-Interscience, New York
Chemical oceanography (Vol. 1), 1975 - Riley, J.P. and Chester, G.
Physical chemistry, 1980 - Glasstone, S.
The geochemistry of natural waters, 1982 - Drever, J.L.
Introduction to geochemistry, 1995 - Krauskopf, K.B. and Bird, McGraw-Hill

ES 581: MARINE BIODIVERSITY AND CONSERVATION
Concept of biodiversity – Biodiversity conservation priorities: values and approaches – Biodiversity of Indian flora and fauna – Economic importance and exploitation of marine organisms along the Indian coast: algae, major penacids and non penacid prawns, crabs, lobsters, horseshoe crabs, dominant mussels (mussels, oysters, clams, gastropods, squids, cuttlefishes and octopuses), holothurians, dominant fish species (mackerels, sardines, pomfrets, bombay duck, seer fishes, tunas, scianids, carangids, sole fishes, silver bellies, ribbon fishes, major sharks, skates and rays) – Protected marine organisms of the Indian Seas: corals, turtles and dugongs.

**Reference books**

Prawn and prawn fisheries of India, 1976 - Kurian, C.V. and Sebastian, V.O.
Marine fisheries, 1984 - Bal, D.V. and Rao, K.V.
Coral reef management handbook, 1984 - Kenchinton, R.A. and Hudson, B.E.T. (Eds.)
Ministry of Environment & Forests, New Delhi notifications on environmental protection

**ES 582 : MARINE GEOPHYSICS**


**Reference books**

Geophysical prospecting for oil, 1976 - Nettleton, L.L., McGraw-Hill
Developments in solid earth geophysics (Vol. 5) Spectral analysis in geophysics, 1974 - Bath Markens
Seismic prospecting instruments (Vol. 1) 1972 - Evenden, B.S., Stone, D.R. and Ansley, N.A.

7. **PROGRAMME EVALUATION**

Programme evaluation will be as stipulated in the PGIS Hand Book 2002.

8. **TEACHING PANEL**

Dr. Champa Amarasiri, NARA, Crow Island, Mattakuliya, Colombo 15
* M.Sc. (Wales), Ph.D. (James Cook)*

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M.Sc., Ph.D.

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Dr. N P Wijayananda, Geological Survey and Mines Bureau, Dehiwala
B.Sc. (Cey.), Ph.D. (London)

Mr. E M S Wijeratne, NARA, Crow Island, Mattakuliya, Colombo 15
M.Sc. (Gothenburg)

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